

**FINAL
COMPLETION REPORT
CHARACTERIZATION WELL R-33
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO
PROJECT NO. 37151**

Prepared for:

The U.S. Department of Energy and the
National Nuclear Security Administration through the
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LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
bgs	below ground surface
°C	degrees Celsius
CD	compact disc
cc	cubic centimeter
cm	centimeter
DOE	U.S. Department of Energy
DTH	down-the-hole
DTW	depth to water
DVD	digital video disc
ELAN	Elemental Analysis
ft	foot/feet
g	gram
gal.	gallon
in.	inch
Kleinfelder	Kleinfelder, Inc.
L	liter
LANL or Laboratory	Los Alamos National Laboratory
mg	milligrams
mS	milliSiemens
NAD	North American Datum
NGVD	National Geodetic Vertical Datum
NM	not measured
NMED	New Mexico Environment Department
NOI	Notice of Intent
NTU	nephelometric turbidity unit
OD	outer diameter
pC	pico Curies
ppm	parts per million
psi	pounds per square inch
RCT	Radiation Control Technician
SAP	Sampling and Analysis Plan
Schlumberger	Schlumberger Water Services
SMO	Sample Management Office
SOP	Standard Operating Procedure
TA	Technical Area
TD	total depth
TOC	total organic carbon
U-234	uranium 234
USACE	U.S. Army Corps of Engineers
WDC	WDC Exploration & Wells

ABSTRACT

Characterization Well R-33 was installed as part of the Los Alamos National Laboratory (LANL) Groundwater Protection Program in accordance with the "Mortandad Canyon Groundwater Work Plan, Revision 1" (LANL 2004). The U.S. Department of Energy contracted and directed the installation of R-33 with technical assistance from LANL. Characterization Well R-33 is located on LANL property within Ten Site Canyon, upgradient from the confluence with Mortandad Canyon, and is intended to serve as a monitoring point for municipal water supply well PM-5 and lower Ten Site Canyon.

Data from R-33 will be used in conjunction with similar data from other wells in the area to improve the conceptual model of the geology, hydrogeology, and hydrochemistry of the area and to provide data for numerical models that address contaminant migration in the vadose (unsaturated) zone and the regional aquifer. The data will be used to evaluate the nature and to define the extent of potential contamination in the regional aquifer in Ten Site and Mortandad canyons relative to former release sites in Technical Area (TA) -48, TA-35, and TA-50.

At R-33, the majority of the fieldwork was conducted from August 2 through December 3, 2004. The borehole was drilled to a depth of 1,140 feet using conventional air-rotary, fluid-assisted air-rotary, and reverse circulation air-rotary methods. Samples of drill cuttings were collected at regular intervals for stratigraphic, petrographic, and geochemical analysis. The stratigraphy encountered during borehole drilling included, in descending order, alluvium, Cerro Toledo Interval, ash-flow tuffs of the Otowi Member of the Bandelier Tuff, the Guaje Pumice Bed of the Otowi Member, Puye Formation, Cerros del Rio basalt, older alluvium, Puye Formation, unassigned pumiceous deposits, and the Totavi Lentil.

The well at R-33 was installed in the regional aquifer with an upper screened interval from 995.5 to 1,018.5 feet (ft) below ground surface (bgs) and a lower screened interval from 1,112.4 to 1,122.3 ft bgs. The depth to water from both screened intervals was 979 ft bgs. Three groundwater-screening samples were collected during drilling. Separate groundwater samples were collected from each screened interval by a two-zone Barcad/Hydro-booster system at the end of aquifer testing. The groundwater samples were submitted to LANL for analysis. Additionally, a constant-rate aquifer test was conducted to determine the aquifer properties of each screened interval.

Overall, the well drilling and construction process was more difficult than anticipated. The borehole was drilled to a shallower depth than originally planned due to the final well location and the difficult drilling conditions. However, sufficient depth into the regional aquifer was reached to satisfy the data quality objectives for the well.

1.0 INTRODUCTION

This completion report summarizes the site preparation, drilling, well construction, well development, aquifer testing, and related activities conducted from August 2 to December 3, 2004, for Characterization Well R-33. R-33 was drilled at Los Alamos National Laboratory (LANL or the Laboratory) as part of the Groundwater Protection Program (LANL 2004), and the work was funded and directed by the U.S. Department of Energy (DOE). Kleinfelder, Inc. (Kleinfelder), under contract to the U.S. Army Corps of Engineers (USACE), was responsible for executing the drilling, installation, testing, and sampling activities.

R-33 is located in Ten Site Canyon, a tributary to Mortandad Canyon, and will serve as a monitoring point for municipal water supply well PM-5 (Figure 1.0-1). Data from R-33 will also help to determine the nature and to define the extent of potential contamination in the regional aquifer in Ten Site Canyon and Mortandad Canyon relative to former release sites in Technical Area (TA) -48, TA-35 and TA-50.

The potential contaminants being investigated in the regional aquifer in this area are radionuclides, metals, nitrate, perchlorate, chloride, sulfate, fluoride, and excessive total dissolved solids, as indicated in the LANL-prepared Sampling and Analysis Plan (SAP; LANL 2003). Data from R-33 will be evaluated in conjunction with data from other area wells, specifically R-1, R-13, R-14, R-15, and R-28, to form the technical basis for the design of a groundwater monitoring system, if needed. Water quality, geochemical, aquifer, and geologic information obtained from R-33 will augment knowledge of regional subsurface characteristics and of the distribution of contaminants in the regional aquifer downgradient of potential release sites.

The information in this report was compiled from field reports and activity summaries generated by Kleinfelder, LANL, and subcontractor personnel. Original records, including field reports, field logs, and survey records, are on file in Kleinfelder's Albuquerque office. Results of these activities are discussed briefly and are shown in tables and figures contained in this report. Detailed analysis and interpretation of geologic, geochemical, and aquifer data will be included in separate technical documents to be prepared by LANL.

2.0 PRELIMINARY ACTIVITIES

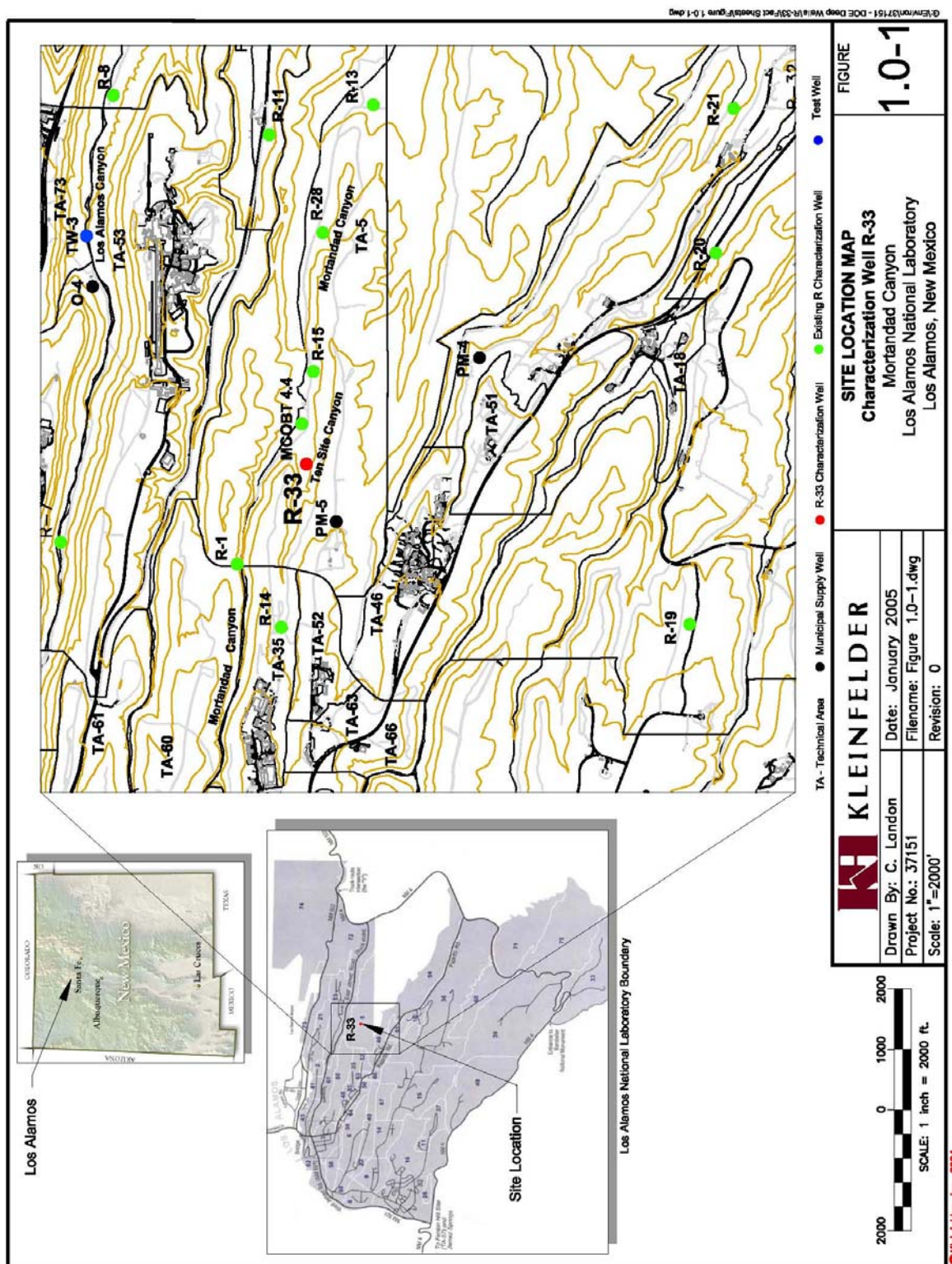
Preliminary activities included administrative preparation and site preparation.

2.1 Administrative Preparation

Kleinfelder received contractual authorization to start administrative preparation tasks in the form of a notice to proceed on June 24, 2004. As part of administrative preparation for Characterization Well R-33, Kleinfelder had previously developed a Project Management Plan (Kleinfelder 2003a), a Contractor's Quality Management Plan (Kleinfelder 2003b), a Site-Specific Health and Safety Plan (Kleinfelder 2003c), and a Drilling Plan (Kleinfelder 2003d) for the work at R-33.

2.2 Site Preparation

EnviroWorks, Inc., was subcontracted by Kleinfelder to conduct the site preparation activities for R-33. Activities included access road improvements, site clearing, construction of a drill pad, and construction of a lined borehole-cuttings containment area.



Site preparation began on August 2, 2004, and the majority of the work was completed by August 6, 2004. Radiation Control Technicians (RCTs) from the LANL HSR-1 group were present to screen the site during preparation activities.

After vegetation was cleared from the drill site, a drilling pad was prepared by grading an area measuring approximately 60 feet (ft) by 150 ft with a front-end loader. Two layers of base-course gravel were distributed, as necessary, over the drill pad, equipment storage area, and access road. To store drilling fluids and borehole cuttings, a 40-ft wide by 60-ft long by 7-ft deep containment area was excavated along the northern pad boundary. Safety barriers and signs were installed around the borehole-cuttings containment area and at the pad entrance.

Office and supply trailers, generators, and safety lighting equipment were moved to the site during the subsequent mobilization of drilling equipment. Potable water was trucked to the site from a hydrant, equipped with a backflow prevention system, next to Building 52-117 on the mesa south of Mortandad Canyon.

3.0 DRILLING ACTIVITIES

The objectives of the drilling activities were to collect cuttings of encountered geologic formations, to collect groundwater samples from significant perched water (if encountered) and the regional aquifer, to provide a borehole for geophysical logging, and to install a multi-screen monitoring well in the regional aquifer. The well will be used for monitoring water levels as well as water quality.

The planned total depth (TD) of the borehole was approximately 1,900 ft below ground surface (bgs) in order to penetrate approximately 100 ft into the regional aquifer. Due to the fact that the R-33 location was moved from a mesa top to the valley floor, it was actually drilled to a TD of 1,140 ft bgs, and the well was completed with two screened intervals within the regional aquifer. Drilling activities were performed generally in one 12-hour shift per day, seven days per week, by the drill crew and two site geologists from August 28 to October 3, 2004.

Figure 3.0-1 presents a borehole summary data sheet and graphically depicts the geology encountered during drilling activities. A chronology of drilling and other project activities, presented in chart form, is provided as Table 3.0-1. Specific details are discussed below.

WDC Exploration & Wells (WDC) drilled R-33 using a GEFECO Speedstar 90K drill rig. The rig was equipped with both conventional- and reverse-circulation drilling rods, tricone bits, down-the-hole (DTH) hammer bits, and support equipment.

R-33 was drilled using air-rotary and fluid-assisted air-rotary drilling techniques. Both conventional and reverse circulation air-rotary methods were used. Drilling fluids were used as needed to improve borehole stability, to minimize fluid loss, and to facilitate cuttings removal from the borehole. Drilling fluids consisted of a mixture of municipal water with QUIK-FOAM[®] surfactant and EZ-MUD[®] polymer. An approximate tally of the total drilling fluids introduced into the borehole, as well as the total drilling fluids recovered, is presented in Table 3.0-2. Depth-to-water (DTW) measurements were taken at the beginning and end of every shift to check for the presence of groundwater.

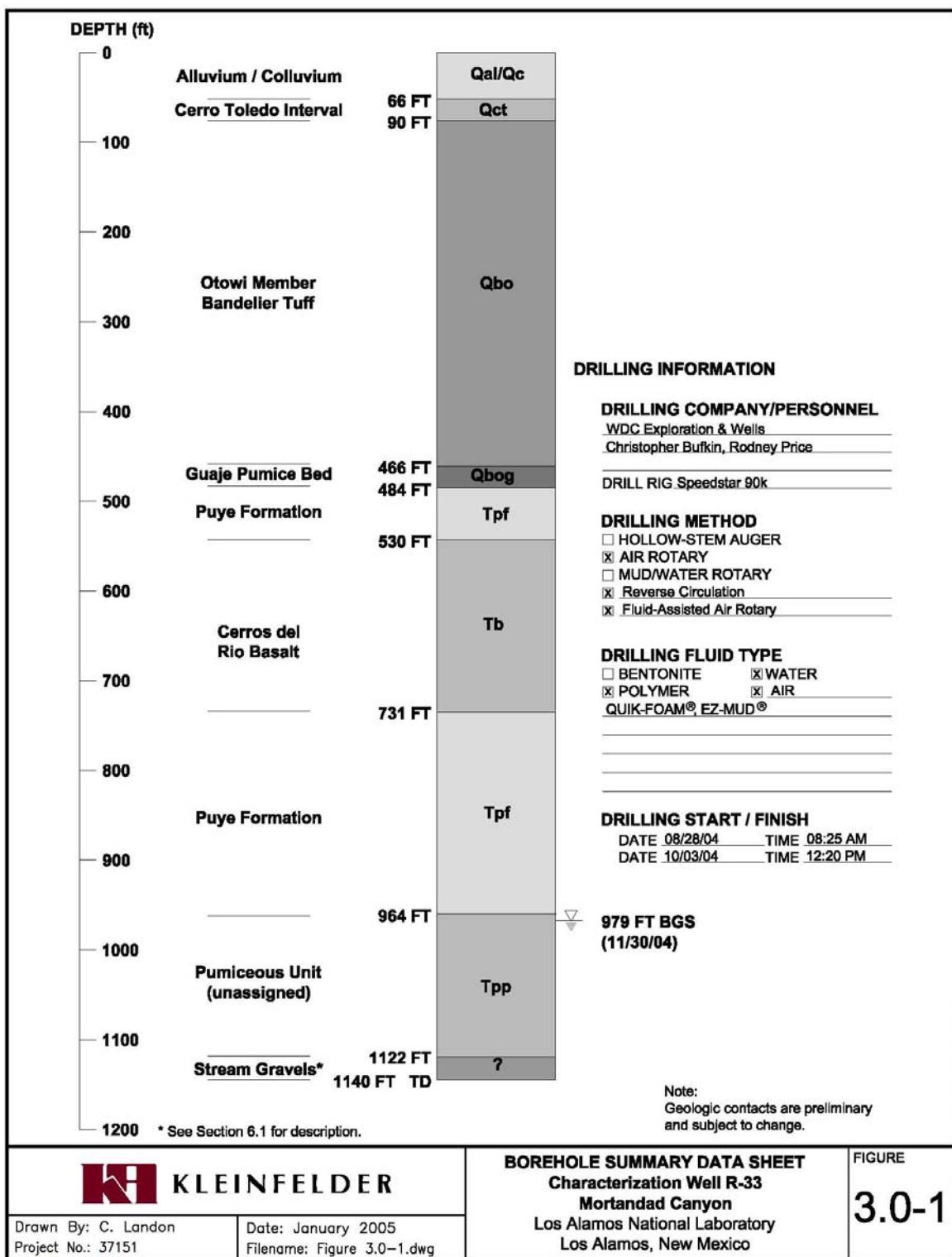


Table 3.0-1
Chronology of Activities at R-33

TASK	Dates of Activity for R-33											
	Aug-04			Sep-04			Oct-04			Nov-04		
SITE PREPARATION ACTIVITIES	8/2 - 8/19											
BOREHOLE DRILLING/SAMPLING				8/28 - 10/3								
Mobilization			8/26 - 8/28									
Air-Rotary Drilling				8/28 - 9/26								
Reverse-Circulation Drilling							9/27 - 10/3					
Groundwater Screening Sampling						9/16						
BOREHOLE GEOPHYSICS												
Schlumberger Geophysical Logging							10/4					
LANL Video Logging			8/29	9/1 - 2	9/8 - 10		10/5					
WELL DESIGN AND CONSTRUCTION							10/5 - 10/13					
WELL DEVELOPMENT									10/25 - 11/11L	11/19 - 11/22U		
GROUNDWATER WELL SAMPLING										11/17L	12/3U	
HYDROLOGIC TESTING										11/14 - 16L	12/2 - 3U	
SITE RESTORATION *												Completed Feb-05

NOTES: * NMED discharge approval was received in an e-mail dated November 10, 2004 (Appendix F). The final phase of site restoration, reseeding, will be complete in the Spring of 2005.

L: Lower Screen U: Upper Screen

Table 3.0-2
Introduced and Recovered Fluids

Material		Amount (Gallons)
Introduced	QUIK-FOAM [®]	446
	EZ-MUD [®]	37
	Potable Water	36,204
	Defoaming Agent	4
	Total Introduced Fluids ^(a)	36,691
Recovered	Total Recovered Fluids ^(b)	171,473

^aTotal Introduced Fluids represents fluids introduced during drilling.

^bTotal Recovered Fluids represents the estimated fluid volume recovered during drilling, well development, and hydrologic testing.

Beginning on August 26, 2004, WDC mobilized drilling equipment and supplies to the R-33 site. On August 28, the drillers began operations by installing temporary 13³/₈-inch (in.) outer diameter (OD) drill casing from the ground surface to a depth of 18.8 ft bgs. The drillers then advanced a 10⁵/₈-in. diameter boring to 225 ft bgs to determine whether groundwater was present in either the alluvium or the Cerro Toledo interval. The borehole encountered the Cerro Toledo interval at a depth of 66 ft bgs and the Otowi Member of the Bandelier Tuff at 90 ft bgs. The drill system was tripped out of the hole, and LANL conducted a video investigation of the borehole the following morning. Because no groundwater was detected in either the alluvium or the Cerro Toledo interval, the 13³/₈-in. diameter casing was removed. The borehole was then reamed out to a 22-in. diameter to a depth of 56.4 ft bgs to set a permanent conductor casing. A 16-in. permanent conductor casing was cemented in place to 56.4 ft bgs.

On August 31, 2004, the borehole below the conductor casing was cleared of slough and opened to a 15-in. diameter with a tricone bit while water was injected for dust suppression. Drilling continued with only water injection to 285 ft bgs, where the drillers began having difficulties clearing cuttings from the borehole. The borehole was then advanced to the top of the basalt with an air-water-foam mixture to lift the cuttings from the borehole. The drill system was then tripped out of the borehole to check for the presence of perched groundwater on top of the basalt. A downhole video investigation conducted on September 1 and 2 encountered approximately 6 in. of very turbid fluid at the bottom of the borehole. Because this was an insufficient volume of groundwater to sample, DOE and LANL staff elected to advance the borehole to the base of the basalt and then run the downhole video again.

On September 2, 2004, the drillers replaced the tricone bit with a DTH hammer and bit. The borehole was then advanced with the air-water-foam mixture to a depth of 735 ft bgs, which was approximately 4 ft into softer material below the basalt. The drill string was tripped out in preparation for the downhole video investigation.

The following morning, a damaged video cable head prevented the downhole inspection. However, a fluid level of 719.55 ft bgs was measured, and a sample of the fluid was collected.

No borehole drilling activities were performed from September 4 to 8, 2004, due to accrued days off. However, LANL personnel performed a downhole video inspection on September 8.

On September 9, 2004, drilling activities resumed with measuring the fluid level (719.25 ft bgs), and an additional fluid sample was collected. Because results for the sampled fluids had not been reported yet, DOE and LANL directed the drillers to stop before the regional aquifer was encountered. Therefore, the borehole was advanced from 735 to 900 ft bgs with the 15-in. DTH hammer system.

The downhole video camera was deployed on September 10 to determine if the fluid associated with the basalts was groundwater, and if so, if sufficient volume was present to justify casing off the borehole before proceeding into the regional aquifer. Based on a review of the downhole video, DOE staff determined that insufficient volume of groundwater was present to warrant casing of the borehole.

On September 11, 2004, drilling resumed with the DTH hammer system and the air-water-foam mixture toward a targeted depth 100 ft below the top of the regional aquifer. At 1,030 ft bgs, there was sufficient evidence that the top of the regional aquifer had been penetrated to warrant stopping to assess borehole stability within the aquifer. Based on potential borehole stability problems at depth within the regional aquifer, DOE and Kleinfelder staff decided to switch to reverse circulation. The full complement of tools required for reverse circulation was not immediately available, and drilling activities ceased until all items were on site.

On September 22, 2004, the reverse circulation equipment was moved onto the R-33 location and the drill system changeover began. By September 28, all parts necessary to run the reverse circulation system were on site, and the system was tripped in. Troubles establishing circulation continued through September 29.

On September 30, 2004, circulation was established, and the borehole was advanced to 1,125 ft bgs with an 11-in. diameter tricone bit. Large clasts encountered at 1,125 ft bgs clogged the reverse-circulation system and required modifications to the bit. On the morning of October 2, modifications were complete, and the borehole was advanced to 1,140 ft bgs. The afternoon of October 2 was spent fighting borehole stability problems. On the evening of October 2, DOE staff declared the borehole complete at the current TD of 1,140 ft bgs.

4.0 SAMPLING AND ANALYSIS OF BOREHOLE DRILL CUTTINGS AND GROUNDWATER

While drilling at R-33, drill cuttings and water samples were collected in accordance with the LANL-prepared SAP. One additional groundwater sample was collected from each screen interval at the end of the respective pumping tests. Groundwater samples were submitted to the LANL Sample Management Office (SMO) for analysis. The groundwater samples were analyzed for organic, inorganic, and radiochemical compounds and geochemical properties. A subset of the cuttings collected from the R-33 borehole will be analyzed for mineralogic, petrographic, and geochemical properties. These samples will be tracked through LANL's scientific logbook chain of custody.

4.1 Sampling of Borehole Drill Cuttings

As drilling conditions permitted, sufficient quantities of cuttings were collected at approximately 5-ft intervals from the borehole waste discharge line. Portions of the cuttings were sieved (using

>#10 and >#35 mesh, or >#35 and >#60 for finer-grained samples) and were placed in chip-trays, along with unsieved cuttings. The cuttings were examined to determine lithologic characteristics and were used to prepare the lithologic logs. An additional aliquot of the >#10 fraction of cuttings was prepared for all intervals where sufficient returns were available. The sieved fractions were placed in labeled plastic bags and were submitted to LANL. The remaining cuttings were sealed in Ziploc[®] bags, labeled, and archived in core boxes. Up to seven samples may be removed by LANL for mineralogic, petrographic, and geochemical analyses. No cuttings samples were submitted for contaminant characterization. However, all cuttings were screened by the RCTs before removal from the site.

Sample analytical results will be included in a future LANL investigation report for Mortandad Canyon.

4.2 Water Sampling

Two samples were collected from the borehole at a DTW of approximately 719 ft bgs, with a borehole total depth of 735 ft bgs. The first sample (GW33-04-53514) was collected on September 3, 2004, and the second sample (GW33-04-53515) was collected on September 9. Another sample (GW33-04-53516) was collected from the top of the regional aquifer on September 16 at a DTW of 979.52 ft bgs and a total borehole depth of 1,030 ft bgs.

Additionally, samples were collected from the completed well. Samples were collected at the end of the pumping test for each screened interval while the screens were isolated from one another. A sample from the lower screened interval was collected on November 17, 2004 (GW33-04-53518), and a sample from the upper screened interval was collected on December 3 (GW33-04-53860). All five samples were submitted to the SMO for analysis.

4.3 Geochemistry of Sampled Waters

The analytical results for the groundwater samples collected from R-33 are in Appendix A. In general, it appears that the two samples collected from the borehole at the 719 to 735 ft bgs interval represented a mixture of drilling fluids, drilling make-up water, and groundwater.

Analytical results for the three regional aquifer samples show that nitrate and perchlorate levels were less than their respective detection limits, 0.01 and 0.001/0.0005 milligrams (mg)/liter (L), respectively.

With the exception of tritium and uranium-234 (U-234), all radionuclide concentrations were less than detection levels. Tritium was undetected in the lower-screened-interval groundwater sample collected after aquifer testing. Tritium was detected in the two groundwater samples collected from 980 to 1,030 ft bgs and 995.5 to 1,018.5 ft bgs (the upper screened interval) at concentrations of 1.02 and 1.05 pico Curies (pCi)/L, respectively. U-234 was detected at concentrations ranging from 0.604 to 1.30 pCi/L in the regional aquifer. Please refer to Appendix A for the complete analytical results presented in tabular format.

5.0 BOREHOLE LOGGING

Using LANL-owned and subcontractor-owned tools, Kleinfelder and Schlumberger ran borehole video and geophysical logging at R-33. Video logs and geophysical logs are included on a digital video disc (DVD) and a compact disc (CD) in Appendixes B and C, respectively.

5.1 Video Logging

LANL personnel ran video logs at R-33 on six separate occasions between August 29 and October 5, 2004, to evaluate the borehole for evidence of water and once at the TD of 1,140 ft bgs (Table 5.1-1).

On August 29, 2004, the borehole was video logged to a depth of 219.6 ft bgs to check for perched water and was found to be dry. Video logging was conducted again on September 1 and 2 to a depth of 529 ft bgs; water with foam was encountered at a depth of 515.1 ft bgs on September 1, and drilling fluid was encountered at 528.6 ft bgs on September 2.

The R-33 borehole was video logged on September 8, 2004, by LANL personnel to a depth of 735 ft bgs. Fluid was encountered in the borehole at 719 ft bgs. On September 10, 2004, the video was run to a depth of 890.5 ft bgs; no water was present.

The final video log for R-33 was run on October 5, 2004, after the TD of 1,140 ft bgs had been reached and geophysical logs had been run. Water was encountered in the borehole at 982.6 ft bgs. Because the final video log shows footage of the entire borehole, it was digitized onto a single DVD included as Appendix B.

**Table 5.1-1
Borehole Logging Conducted**

Operator	Date	Cased Footage (ft bgs)	Open-hole Interval (ft bgs)	Remarks	Tools
LANL	8/29/04	0-18.2	18.2-219.6	Check for perched water; hole was dry	Video Camera
LANL	9/1/04	0.7-56.4 ^a	56.4 ^a -529	Water with foam at 515.1 ft bgs	Video Camera
LANL	9/2/04	0.7-56.4 ^a	56.4 ^a -529	Drilling fluid at 528.6 ft bgs	Video Camera
LANL	9/8/04	0.7-56.4 ^a	56.4 ^a -735	Fluid at 719 ft bgs	Video Camera
LANL	9/10/04	0.7-56.4 ^a	56.4 ^a -900	Ran to 890.5; hole was dry	Video Camera
Schlumberger	10/4/04	0.7-56.4 ^a	56.4 ^a -1,140	Geophysics suite run at TD	Combinable Magnetic Resonance; Compensated Neutron Log; Elemental Capture Spectroscopy; Triple Litho Density; Array Induction; Formation Micro-Imager; Inclination; Elemental Capture Spectroscopy; Gamma Ray Caliper; Natural Gamma Spectroscopy; Gamma Ray
LANL	10/5/04	0.7-56.4 ^a	56.4 ^a -1,140	Video log was run from surface to top of water at 982.6 ft bgs	Video Camera

^aSchlumberger reported the depth to the bottom of the surface casing as 56 ft bgs.

5.2 Geophysical Logging

Geophysical logs were run in R-33 on October 4, 2004 by Schlumberger personnel at the TD of 1,140 ft bgs. The purpose of geophysical logging was to identify geologic and hydrogeologic units, with an emphasis on gathering moisture-distribution data, identifying water-bearing zones, measuring capacity for flow (porosity and moisture), and obtaining lithologic/stratigraphic data. Secondary objectives included evaluating borehole geometry and determining the degree of drilling fluid invasion along the borehole wall. The suite of geophysical tools used at R-33 is shown in Table 5.1-1. The complete geophysical report and all logging runs are presented on a CD included in Appendix C.

6.0 LITHOLOGY AND HYDROGEOLOGY

A preliminary description of the hydrogeologic features encountered during the drilling of R-33 is presented below. This section includes descriptions of geologic units identified during characterization of the cuttings and a review of geophysical logs. LANL EES-6 staff provided preliminary interpretation of geologic contacts. Groundwater occurrences are interpreted from drilling observations, open-hole video logging, geophysical logging, and water-level measurements.

6.1 Stratigraphy and Lithology

Rock units and stratigraphic relationships were interpreted are based on visual examination of the borehole drill cuttings, on preliminary interpretation of the geophysical data, and on geophysical logs. The drill cuttings from R-33 commonly contained material derived from one or more geologic units. The interpretations presented below are discussed in order of younger to older occurrence, and may be revised upon additional analysis of petrographic, geochemical, mineralogical, and geophysical logging data. A lithologic log of the borehole containing detailed descriptions that identify the texture and composition of sample intervals is in Appendix D.

Alluvium/Colluvium, Qal/Qc (0 to 66 ft bgs)

Cuttings collected from the borehole indicate that unconsolidated alluvium and colluvium is present from the ground surface to approximately 66 ft bgs. Samples collected from 0 to 66 ft bgs consisted of unconsolidated silt, sands, and gravels typically composed of volcanic lithics, tuff fragments, and quartz crystals. The composition is comparable to that of the Bandelier Tuff from which these sediments are likely derived.

Cerro Toledo interval, Qct (66 to 90 ft bgs)

The Cerro Toledo interval was encountered in the borehole between 66 and 90 ft bgs. These volcanoclastic deposits range in size from well-graded sand to well-graded sand with gravel. The coarse fraction (i.e., the >#10 sieve size) in this interval is made up of tuff, vitric pumice, crystals, and intermediate volcanic lithics. The fine fraction (i.e., the >#35 sieve size) is made up of tuff and pumice, crystals, and lithics, with trace obsidian. Pumice with manganese/iron oxide staining and increasing percentages of small surficial manganese/iron oxide specks were noted from 80 to 90 ft bgs.

Otowi Member, Bandelier Tuff, Qbo (90 ft to 466 ft bgs)

Rhyolitic ash-flow tuff representing the Otowi Member of the Bandelier Tuff was intersected in the borehole from 90 to 466 ft bgs. Cuttings showed that the Otowi Member is locally pumiceous, lithic-bearing, and poorly welded. The coarse fraction from this interval commonly

consists of volcanic lithic fragments of intermediate volcanic composition, including hornblende and biotite dacite with iron staining, andesite, vitric pumices, and varied percentages of felsic (quartz and sanidine) crystals. The fine fraction is made up predominantly of quartz and sanidine crystals, with subordinate amounts of volcanic lithics and pumice.

Guaje Pumice Bed, Bandelier Tuff, Qbog (466 ft to 484 ft bgs)

The Guaje Pumice Bed, encountered from 466 to 484 ft bgs, is made up of pumice-fall deposits that form the basal subunit of the Otowi Member of the Bandelier Tuff. The coarse fraction from this poorly welded interval consists of vitric pumice with traces of phenocrysts and lithic fragments. The fine fraction is predominantly felsic crystals and vitric pumice with subordinate amounts of lithic fragments.

Puye Formation, (fanglomerate) Tpf (484 to 530 ft bgs)

Geophysical logging identified the Puye Formation from 484 to 530 ft bgs. The cuttings from the upper 20 feet are indicative of the Guaje Pumice Bed and show the interval as poorly welded tuff. The cuttings from the lower formation show volcanoclastic sediments deposited as silty sand with gravel. The presence of Guaje Pumice Bed lithologies in this interval is due to mixing of cuttings from several stratigraphic horizons caused by air circulation in the upper part of the borehole. The coarse fraction consists of lithics and pumice with biotite and felsic phenocrysts, lithic clasts of hornblende and biotite dacite, and sandstone. The fine fraction consists of predominantly lithics with subordinate amounts of pumice, felsic crystals, and sandstone fragments.

Cerros del Rio Basalt, Tb (530 to 731 ft bgs)

The Cerros del Rio basalt, comprised of basaltic lavas, was encountered in the borehole from 530 to 731 ft bgs. Cuttings indicated that the upper portion of this section, from 530 to about 645 ft bgs, consists of medium to dark gray, massive to vesicular basaltic lava that contains occasional phenocrysts (olivine and rare plagioclase) in an aphanitic groundmass. The groundmass exhibits minor weathering and/or alteration. From 645 to 670 ft bgs, the cuttings are red and gray, weakly porphyritic, and vesicular with clay-coated vesicles. The interval from 670 to 731 ft bgs is blue-gray massive basaltic lava (as noted above), fine sandstone, pumice, and manganese oxide stained clay.

Puye Formation (fanglomerate), Tpf (731 to 964 ft bgs)

The fanglomerate section of the Puye Formation was encountered in the borehole from 731 to 964 ft bgs, though the upper interval from 731 to 746 ft bgs contains abundant basalt clasts in stratified gravels. This section provided inconsistent sample returns of volcanoclastic sediments deposited as silty sand, sands, and gravels. The coarse and fine fractions primarily consist of clasts of intermediate volcanic composition including andesite, rhyodacite, black and red vitrophyres, and various porphyritic clasts with minor amounts of sandstone, quartz, and plagioclase fragments.

Pumiceous unit, unassigned, Tpp (964 to 1,122 ft bgs)

The unassigned pumiceous section of the Puye Formation was encountered in the borehole from 964 to 1,122 ft bgs. This section consists of volcanoclastic sediments deposited as silty sand, sands, and gravels. Coarse- and fine-fraction samples primarily consisted of angular to subangular clasts of dacite and white vitric pumice, with lesser amounts of obsidian, vitrophyres, siltstone, hornblende dacite, biotite dacite, and felsic crystals.

Stream gravels (1,122 to 1,140 ft bgs)

Stream gravels of indeterminate origin were encountered in the borehole from 1,122 to the TD of 1,140 ft bgs. This interval consists of volcanoclastic sediments with subordinate Precambrian quartzite and granite deposited mostly as silty sand with trace gravel. The coarse and fine fractions primarily consist of felsic porphyritic fragments of intermediate composition, including hornblende dacite and quartzite, with lesser amounts of pumice and crystals.

6.2 Groundwater Occurrence and Characteristics

The SAP indicated that there could possibly be three perched groundwater zones in the area of R-33 and that the regional aquifer would be encountered in the Puye Formation at approximately 1,258 ft bgs. This water table prediction was based on a borehole location that was originally sited on a mesa top to the south. Possible perched zones could be encountered in the Cerro Toledo interval, in the Guaje Pumice bed, and in association with the Cerros del Rio basalt.

During borehole drilling, two aqueous samples (GW33-04-53514 and GW33-04-53515) were collected from a depth between 719 and 735 ft bgs at the base of the Cerros del Rio basalt to determine if perched groundwater was present. A third aqueous sample (GW33-04-53516) was collected from the borehole at a depth between 979.52 and 1,030 ft bgs. This sample represents the top of the regional aquifer, which was much shallower than predicted because the well location was moved from the mesa top to the canyon floor. Upon well completion and development of R-33, groundwater samples (GW33-04-53518 and GW33-04-53860) were obtained from the lower and upper screened intervals (1,112.4 to 1,122.3 ft bgs and 995.5 to 1,018.5 ft bgs, respectively).

The processed geophysical logs indicate a significant increase in water saturation below 984 ft bgs, which is consistent with the well water level at the time of the logging. The estimated pore-volume water saturation (fraction of the total pore volume containing water) computed from the Elemental Log Analysis (ELAN) is very high (mostly above 90%) from 984 ft bgs to the bottom of the log interval (1,131 ft bgs), compared with 40 to 60% in the interval directly above 984 ft bgs. The estimate is similarly high when computed directly from bulk density and ELAN water-filled porosity for a grain density range of 2.35 grams (g)/cubic centimeter (cc) to 2.75 g/cc. These results suggest that the regional aquifer groundwater level may reside at 984 ft bgs in this location, with the regional aquifer below. Before aquifer testing, on November 30, 2004, the static water level was measured at 979 ft bgs.

7.0 WELL DESIGN AND CONSTRUCTION

Following approval of the well design by DOE, LANL, and the New Mexico Environment Department (NMED), Kleinfelder received the final construction specifications for R-33 on October 5, 2004. Well installation activities were performed from October 5 to October 13, 2004.

7.1 Well Design

Data from geophysical logs and borehole cuttings, as well as from field water-level measurements and field observations, were evaluated to determine the placement of the screened intervals for the well. Design of the well was performed in accordance with LANL ER SOP-05.01 (Standard Operating Procedure for Well Construction, Revision 3) (LANL 2001), and an approved well design was provided to Kleinfelder by DOE and LANL. The well was designed with two screened intervals (995.5 to 1,018.5 ft bgs and 1,112.4 to 1,122.3 ft bgs) to

monitor potential contaminants and groundwater chemistry in the two uppermost productive zones of the regional aquifer and to determine if vertical hydraulic gradients are present in this part of the Laboratory.

7.2 Well Construction

R-33 was constructed of 4.5-in. inner diameter/5.0-in. OD, type A304, stainless-steel casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. Two nominal 12-ft lengths (10 ft of screen openings each) of 5-in. OD compatible, 0.020-in. rod-based, wire-wrapped well screens were used for the upper screen and one for the lower screen. The casing and screens were factory-cleaned before shipment and delivery to the site. Additional decontamination of the stainless-steel components was performed on site before well construction using a high-pressure steam cleaner. Stainless-steel casing was placed below the screens to construct a 3.7-ft deep sump. External couplings, also of type A304 stainless steel fabricated to ASTM A312 standards, were used to connect individual casing and screen joints. The 16-in. drill casing remained in the borehole during construction of the screened intervals to maintain hole stability through the alluvium. Centralizers were placed immediately below and above the lower screen; immediately below, at the screen joint, and above the upper screen; and 100 ft above the top of the upper screen. Figure 7.2-1 is an as-built schematic of the completed well.

Below the top of the regional aquifer, annular fill was placed into the borehole by using a 2.5-in. OD steel tremie pipe to deliver various materials to specified backfill intervals. Above the top of the regional aquifer, backfill material was poured from the surface and hydrated through the tremie.

Before running the well casing into the hole, the bottom of the borehole was tagged at 1,126 ft bgs. To keep bentonite from contacting the screen, a bottom hole seal was not installed. Instead, backfilling of the annulus began with the sand filter pack. A primary filter pack consisting of 10/20 silica sand was placed across the lower screened interval from 1,126 to 1,107 ft bgs. After placement of the primary filter pack, a WDC development rig swabbed the screened interval to promote settling and compaction. A fine sand collar of 20/40 silica sand was then placed above the primary filter pack from 1,107 to 1,105 ft bgs. A 78-ft thick bentonite seal was installed above it to separate the lower screened interval filter pack from the upper. A primary filter pack consisting of 10/20 silica sand was then placed across the upper screened interval from 1,027 up to 991 ft bgs. After placement of the primary filter pack, a WDC development rig again swabbed the screened interval to promote settling and compaction. A fine sand collar of 20/40 silica sand was then placed above the primary filter pack from 991 up to 988 ft bgs.

A bentonite seal was emplaced above the top of the upper fine sand collar from 988 to 74 ft bgs. During the emplacement, a bentonite bridge formed in the unsaturated zone from 533 to 643 ft bgs. The bottom of the tremie was at 800 ft bgs at the time, so the void below 643 ft was filled by pumping backfill material through the tremie. After the void was filled, backfilling continued to 74 ft bgs with the seal being hydrated after each 3,000-pound supersack of bentonite was added. The 16-in. conductor casing was left in place and was filled with the concrete mix. The concrete backfill consisted of 2,500 pounds per square inch (psi) concrete with 3% bentonite. Quantities of annular fill materials used are presented in Table 7.2-1.

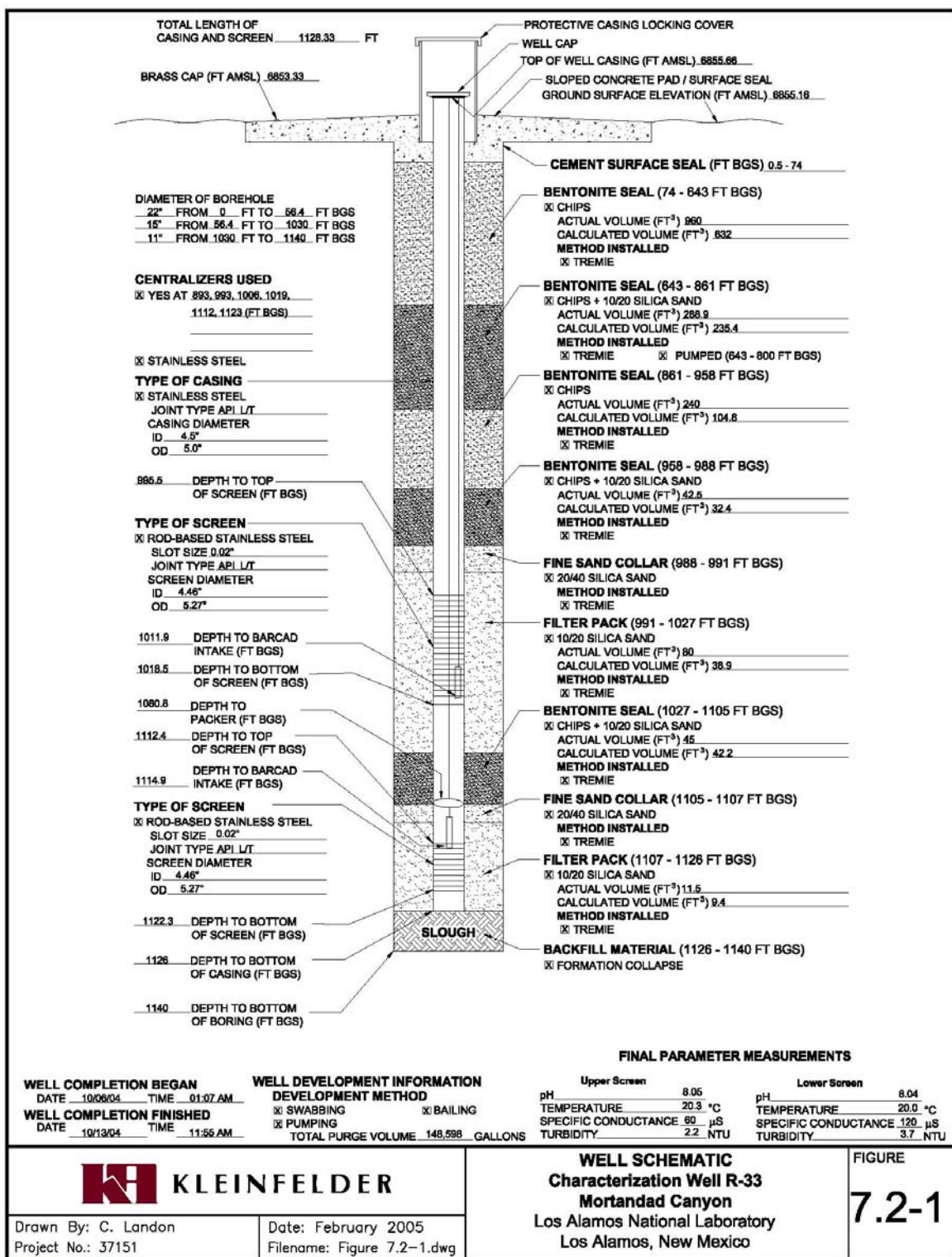


Table 7.2-1
Annular Fill Materials Used in Well Construction

Material	Volume
Surface Seal: cement slurry	94.5 ft ³
Bentonite chips	1200 ft ³
Bentonite chips and 10/20 silica sand ^a	376.4 ft ³
Fine Sand Collar: 20/40 silica sand	8 ft ³
Primary Filter: 10/20 silica sand	91.5 ft ³
Potable Water	31,600 gallons

^a Bentonite to sand ratio was 45:55 by volume.

8.0 WELL DEVELOPMENT AND AQUIFER TESTING

Well development activities for R-33 occurred between October 25 and November 22, 2004. Well development procedures included bailing, well screen swabbing, and pumping. Constant rate pumping and recovery aquifer tests were run on the lower screened interval (1,112.4 to 1,122.3 ft bgs) from November 14 to 16, and on the upper screened interval (995.5 to 1,018.5 ft bgs) from December 1 to 3. A total of 148,598 gallons (gal.) of water were removed during well development and aquifer testing activities.

The following list presents, in chronological order, the R-33 well development and aquifer testing activities:

- Bailing and swabbing of both screened intervals
- Development of both zones with a submersible pump (without a packer)
- Aquifer testing of the lower screened interval with a packer
- Final development of the lower screened interval with packer in place
- Aquifer testing of the upper screened interval (which effectively completed development)

8.1 Well Development

The primary objective of well development was to remove suspended sediment from the water until turbidity was less than 5 nephelometric turbidity units (NTUs) for three consecutive samples. Additional water quality parameters measured during development included pH, temperature, specific conductance, and total organic carbon (TOC); parameters were required to stabilize before termination of development procedures. The goal was for TOC levels to be less than 2.0 parts per million (ppm), indicating that all drill foam residues were removed from the well. Table 8.1-1 summarizes the volumes of water removed during development and the accompanying water quality parameters.

R-33 was initially developed by bailing and swabbing the two screened intervals and sump to remove bentonite materials, drilling fluids, and formation sands and fines that had been introduced into the well during drilling and installation. Bailing was conducted by WDC using a 3.5-gal. capacity, 3-in. OD by 10-ft long stainless steel bailer. Bailing continued until water clarity visibly improved. After bailing approximately 40 gal., the two screened intervals were swabbed on October 25, 2004, to enhance filter pack development. The swabbing tool was a 4.25-in. OD, 1-in. thick rubber disc attached to the drill rod; it was lowered into the well and drawn repeatedly across the screened intervals for approximately 1 hour. Water turbidity was not measured during the bailing and swabbing processes.

Table 8.1-1
Water Removed and Final Water Quality Parameters
During Well Development and Aquifer Testing

Method	Water Removed (gallons)	pH	Temperature (°C)	Specific Conductance (mS/cm)	Turbidity (NTU)	Total Organic Carbon (ppm)
(10/25/04) Bailing/Swabbing Screens	40	NM	NM	NM	NM	NM
(10/27 – 11/9/04) Pumping Lower Screened Interval	68,443	8.04	20.00	0.12	3.72	1.96
(11/9 – 11/11/04) Pumping Upper Screened Interval	19,147	8.05	20.30	0.06	2.23	3.45
(11/14 – 11/16/04) Aquifer Test – Lower Screened Interval	21,153	NM	NM	NM	NM	3.31
(11/19 – 11/22/04) Pumping Lower Screened Interval (w/packer in place)	34,550	NM	NM	NM	3.0	1.83
(12/1 – 12/3/04) Aquifer Test – Upper Screened Interval (w/packer)	5,265	NM	NM	NM	NM	1.79
Total	148,598	–	–	–	–	–

NM: Not Measured

A 7.5-horsepower, 4-in. Grundfos submersible pump was used for the final stage of well development. During the first phase of pumping development, the pump intake was set in multiple locations within the lower screened interval, and 68,443 gal. of water were removed; then, the pump was raised to the upper screened interval and an additional 19,147 gal. were removed as the pump intake was again set in multiple locations. A packer was not used during the first phase of pumping. Water samples were collected to measure water quality parameters; Figure 8.1-1 shows the effect of well development on the water quality parameters.

An inflatable packer was emplaced between the two screened intervals during the first phase of aquifer testing for the lower screened interval. The packer allowed the two water-bearing zones to be tested independently of one another. Following aquifer testing, the TOC value in the lower zone was still elevated, and the packer was left in place so that the interval could be isolated and properly developed. Well development continued in the lower zone until the turbidity was less than 5 NTUs and the TOC levels were less than 2.0 ppm. Figure 8.1-2 shows the turbidity levels

during development. An additional 34,550 gal. were removed from the lower zone during the second phase of development.

After the second phase of development, aquifer tests were conducted on the upper zone. A bridge plug was set below the upper screen to isolate the two zones. Water quality parameters measured after pump testing of the upper zone indicated that the testing had effectively completed well development of that zone, and no further well development was required.

8.2 Aquifer Testing

Constant-rate pumping tests were performed on each screened zone in R-33; the two screened zones were isolated by an inflatable packer during the pumping tests. A summary of the pumping tests and accompanying data are presented in Appendix E. The following information summarizes the key results from the aquifer pumping tests:

- The barometric efficiency of the upper zone was very high, consistent with barometric efficiencies measured in the other regional wells. However, the barometric efficiency of the lower zone was very low – the first screened zone to display a low barometric efficiency.
- The piezometric level for the upper zone was 7.4 ft higher than the composite static water level, whereas the piezometric level for the lower zone was 18.9 ft lower. The net difference in the two levels was 26.3 ft, indicating a strong downward gradient and an intervening aquitard between the two screens.
- The hydraulic conductivity of the upper zone ranged between 4.5 and 7.0 ft per day; the hydraulic conductivity of the lower zone ranged between 1.3 to 2.4 ft per day.

8.3 Dedicated Sampling System Installation

A two zone Barcad/Hydrobooster system was installed as the permanent groundwater sampling system at R-33. The Barcad is a gas displacement pump capable of lifting groundwater from the depths encountered in R-33. The Hydrobooster is a volume booster that greatly expedites the groundwater sampling process.

Best Environmental Subsurface Sampling Technology (BESST), Inc., owner of the Barcad and Hydrobooster technology, prepared an installation design that was approved by the DOE (Figure 7.2-1). BESST staff installed the system February 3 to 5, 2005. The upper screen system consists of a nominal 27 ft Hydrobooster above the Barcad pump intake at 1,011.5 ft bgs. The lower screen sampling system consists of a nominal 27 ft Hydrobooster above the Barcad pump intake at 1,114.9 ft bgs. The two sampling systems are separated by an inflatable packer placed just above the lower screen. Each zone has a dedicated pressure transducer reading in absolute pressure with a data logger at the ground surface.

8.4 Wellhead Completion

On October 25, 2004 a reinforced 2,500-psi concrete pad, 5-ft wide by 5-ft long by 6-in. thick, was installed around the well casing to provide long-term structural integrity for the well. A brass survey cap was embedded in the northwest corner of the pad. A 10.75-in. diameter steel casing with locking lid protects the well riser. The pad was designed to be slightly elevated, with base-course gravel graded up around the pad to provide a safe and level working surface for future sampling events.

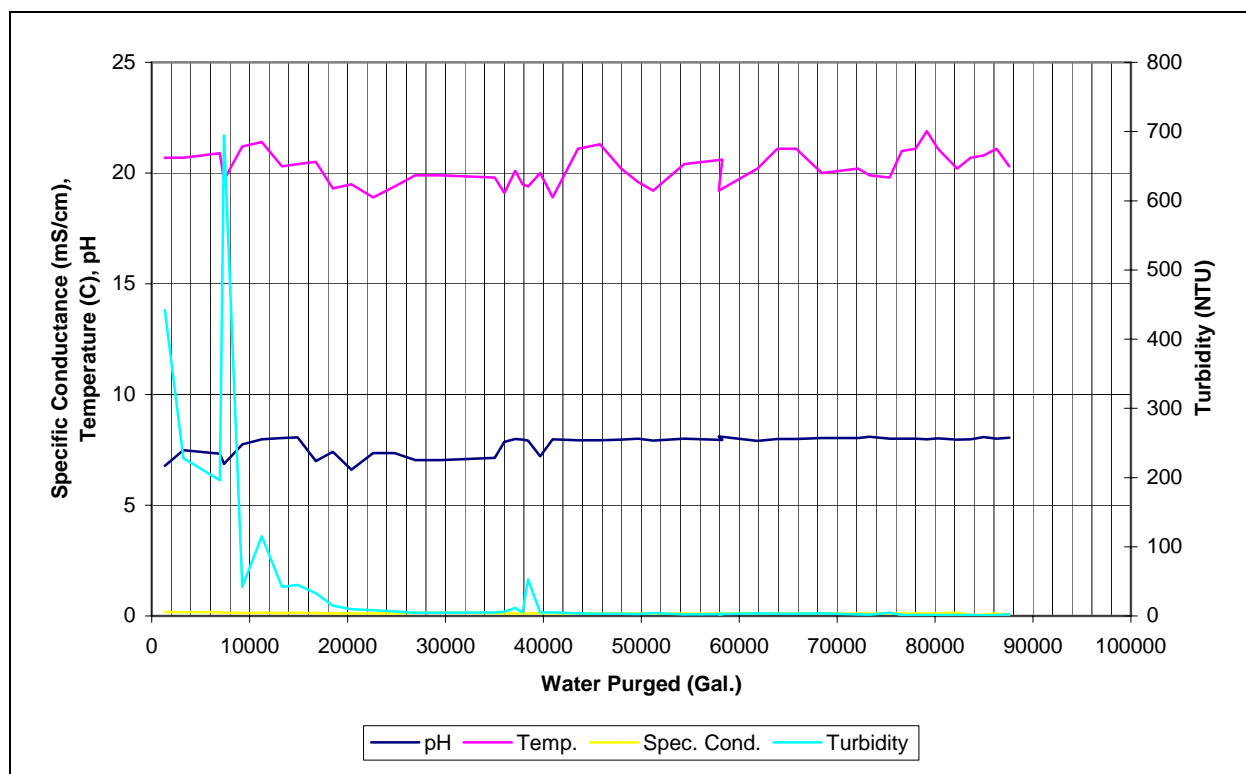


Figure 8.1-1. Effects of Well Development on Water Quality Parameters for Both Screened Intervals

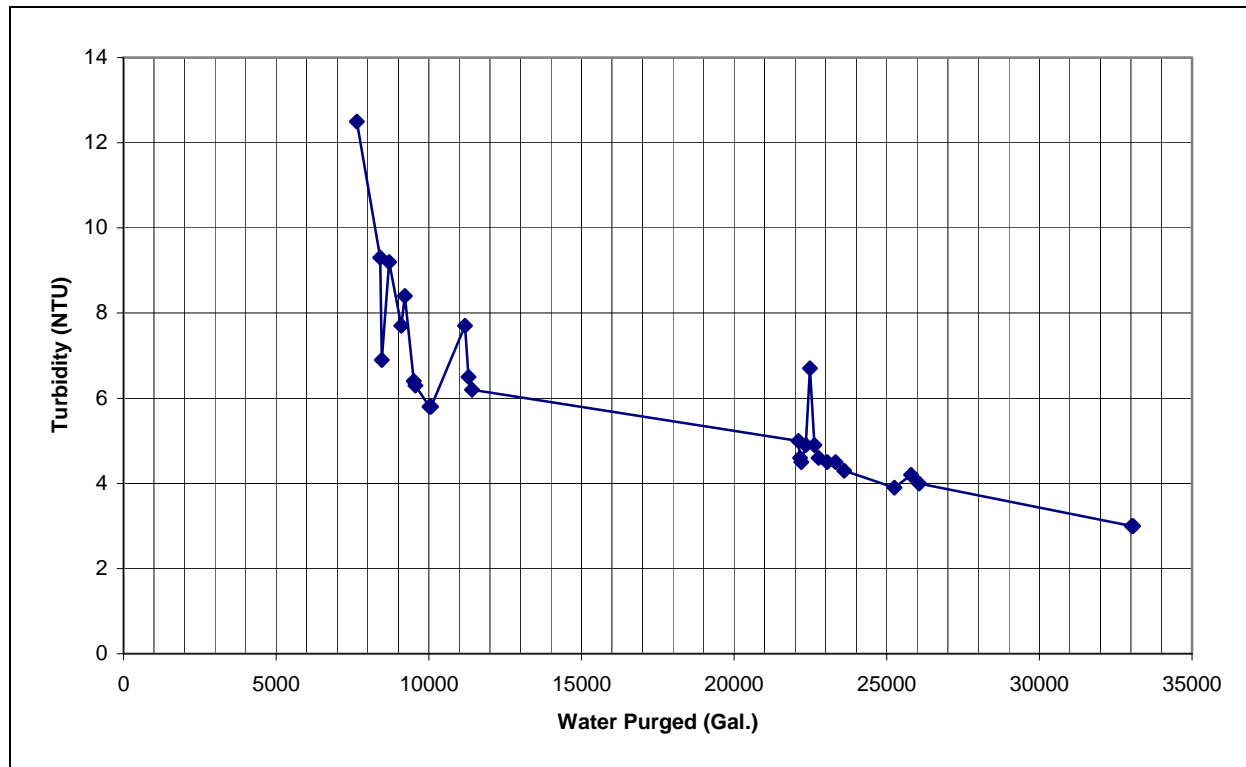


Figure 8.1-2. Effects of Well Development on Turbidity for Lower Screened Interval

8.5 Geodetic Survey

The location of the well was determined by geodetic survey on November 8, 2004; Lynn Engineering and Surveying, Inc., conducted the survey. Coordinates and elevations were obtained from LANL Monument MCOBT-4.4 using static Global Positioning System observation.

This survey located the brass cap monument in the concrete pad around the well and the top of the stainless steel well casing. Table 8.5-1 summarizes the readings recorded for these components of the completed wellhead. The coordinates shown are New Mexico State Plane Grid Coordinates, Central Zone (North American Datum of 1983), expressed in feet. Elevation is expressed in feet above mean sea level relative to the National Geodetic Vertical Datum of 1929.

Table 8.5-1
Geodetic Data

Description	Northing	Easting	Elevation ^a
Brass cap in R-33 pad	1768532.65	1633401.71	6853.33
Top of stainless-steel casing	1768531.32	1633403.64	6855.56

^a Measured in feet above mean sea level (amsl) relative to the National Geodetic Vertical Datum of 1929.

8.6 Site Restoration

Fluids and cuttings produced during drilling and development were sampled in accordance with the “Notice of Intent to Discharge, Hydrogeologic Workplan Wells,” and filed with the NMED. Approval to discharge drilling and development water was received from NMED on November 10, 2004. A copy of the NMED discharge approval and the sample analytical results are included in Appendix F.

Water was removed from the cuttings pit and applied to the land surface. The liner was removed from the pit and the berms were removed. The pit was backfilled and graded and drill cuttings were spread over the ground surface after receipt of NMED approval (Appendix F).

Temporary fencing and straw bales were left in place to minimize possible erosion and sedimentation impacts from future precipitation. The fencing will stay in place until 70% regrowth of the seedlings has been achieved.

9.0 DEVIATIONS FROM THE SAP

Appendix G compares the actual drilling and well construction activities performed at R-33 with the planned activities described in the SAP (LANL 2003). For the most part, drilling, sampling, and well construction at R-33 was completed as specified in the SAP. The main deviation from planned activities is summarized as follows:

- Planned Borehole Depth – The SAP stipulated that the borehole be drilled to a TD of 1,900 ft bgs, or approximately 642 ft below the regional water table, which was projected to occur at 1,258 ft bgs. At the direction of DOE personnel, the well was

moved from a mesa top down to the Ten Site Canyon floor. The proposed depth of penetration into the regional aquifer was not possible due to borehole instability. The completed R-33 borehole was drilled to a TD of 1,140 ft bgs, which was 161 ft below the measured depth to the regional water table (979 ft bgs).

10.0 ACKNOWLEDGMENTS

D. Schafer of Schafer and Associates contributed the aquifer testing section of this report.

EnviroWorks, Inc., provided site preparation and restoration activities.

Lynn Engineering & Surveying, Inc., conducted the final geodetic survey of finished well components.

N. Clayton of Schlumberger provided processing and interpretation of borehole geophysical data.

P. Longmire of Los Alamos National Laboratory contributed the geochemistry section of this report.

Tetra Tech EM, Inc., provided support for site geology, sample collection, and aquifer testing.

WDC Exploration & Wells provided rotary drilling services.

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